GENERAL APTITUDE

1.

Items	Cost (₹)	Profit %	Marked Price
P	5, 4000	…	5,860
Q	…	25	10,000

Details of prices of two items P and Q are presented in the above table. The ratio of cost item P to cost of item Q is 3:4. Discount is calculated as the difference between the marked price and the selling price. The profit percentage is calculated as the ratio of the difference between selling price and cost, to the cost

$$\left(\text{Profit }\% = \frac{\text{Selling price} - \text{Cost}}{\text{Cost}} \times 100\right)$$

The discount on item Q, as a percentage of its marked price, is _____ **[2-Marks, MCQ]**

(A) 25 (B) 10 (C) 12.5 (D) 5

Key: (B)

Given: Ratio of cost of item P to cost of item Q = 3 : 4

Cost of item P = 5400

Cost of item Q = 7200

Profit % on item Q = 25

∴ Selling price of item Q = $7200 \times \frac{125}{100} = 9000$

∴ Discount of item Q = Marked price – selling price

$= 10,000 - 9000 = 1000$

∴ Discount % = $\frac{1000}{10,000} \times 100 = 10$

2. Given below are two statements 1 and 2, and two conclusions I and II.

Statement 1: All bacteria are microorganisms.

Statement 2: All pathogens are microorganisms.

Conclusion I: Some pathogens are bacteria.

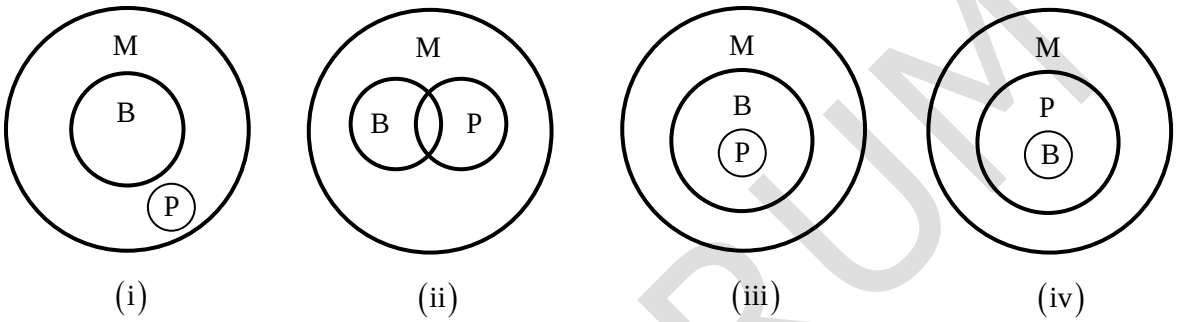
Conclusion II: All pathogens are not bacteria.

Based on the above statements and conclusions, which one of the following options is logically CORRECT? **[2-Marks, MCQ]**

(A) Only conclusion II is correct
(B) Either conclusion I or II is correct
(C) Neither conclusion I nor II is correct
(D) Only conclusion I is correct

Key: (C)

Sol: Using Venn diagrams, the different possibilities are



From figure (i), conclusion I is incorrect

From figure (ii), conclusion II is incorrect

Hence, neither conclusion I nor II is correct

3. There are five bags each containing identical sets of ten distinct chocolates. One chocolate is picked from each bag. **[2-Marks, MCQ]**

(A) 0.6976 (B) 0.3024 (C) 0.8125 (D) 0.4235

Key: (A)

Sol:

Total number of cases in sample space $= 10\times10\times10\times10\times10 = 10^5$

Event A $\rightarrow$ At least two chocolates are identical

Probability of A, ie., $P\begin{pmatrix}\text{atleast two are}\\ \text{identical}\end{pmatrix} = 1 - P(\text{alldifferent})$

$$\Rightarrow P(A) = 1 - \frac{10\times9\times8\times7\times6}{10^5}$$
$$= 1 - 0.3024 = 0.6976$$

4. Consider the following sentences: **[1-Mark, MCQ]**

(i) Everybody in the class is prepared for the exam.

(ii) Babu invited Danish to his home because he enjoys playing chesss.

Which of the following is the CORRECT observation about the above two sentences?

(A) (i) is grammatically incorrect and (ii) is unambiguous

(B) (i) is grammatically correct and (ii) is unambiguous

(C) (i) is grammatically correct and (ii) is ambiguous

(D) (i) is grammatically incorrect and (ii) is ambiguous

Key: (C)

Sol: **(i)** is grammatically correct and

(ii) is ambiguous.

Statement 2 is ambiguous because we do not know who enjoys playing chess, Babu or Danish !!

Statement 1 is grammatically correct.

5. The ratio of boys to girls in a class is 7 to3. **[1-Mark, MCQ]**

Among the options below, an acceptable value for the total number of students in the class is:

(A) 21 (B) 73 (C) 37 (D) 50

Key: (D)

Sol: Given: Ratio of boys to girls

$\therefore$ Multiples of 10 are : 10, 20, 30, 40, 50, 60, 70,.....

$\therefore$ An acceptable value for the total number of students is 50.

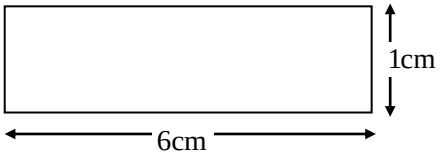
6. We have 2 rectangular sheets of paper, M and N, of dimension 6 cm × 1 cm each. Sheet M is rolled to form an open cylinder by bringing the short edges of the sheet together. Sheet N is cut into equal square patches and assembled to form the largest possible closed cube. Assuming the ends of the cylinder are closed, the ratio of the volume of the cylinder to that of the cube is _____. **[2-Marks, MCQ]**

(A) 3π (B) $\frac{9}{\pi}$ (C) $\frac{3}{\pi}$ (D) $\frac{\pi}{2}$

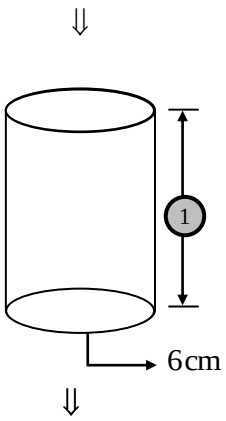
Key: (B)

Sol: Given:

Sheet M

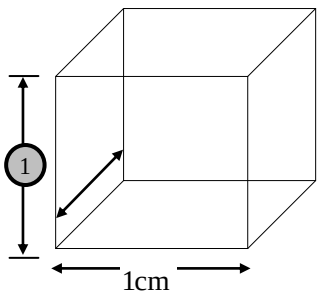


Sheet N



Volume of cylinder
$V = \pi r^2 h$;
where $h = 1$, r is maximum
But $2\pi r = 6cm$
$\Rightarrow r^2 = \frac{6}{2\pi} = \frac{3}{\pi}$

$\therefore V = \pi\left(\frac{3}{\pi}\right)^2 (1) \Rightarrow V = \frac{9}{\pi} cm^3$



Volume of unit cube =1cm

Required ratio $= \frac{\frac{9}{\pi}}{(1)} = \frac{9}{\pi}$

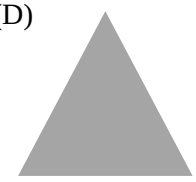
7. A polygon is convex if, for every pair of points, P and Q belonging to the polygon, the line segment PQ lies completely inside or on the polygon.

Which one of the following is NOT a convex polygon? **[1-Mark, MCQ]**

(A) 

(B) 

(C) 

(D) 

Key: (B)

Sol: Here line segment does not lie inside of on the polygon.

Hence the figure in option (B) is not a convex polygon

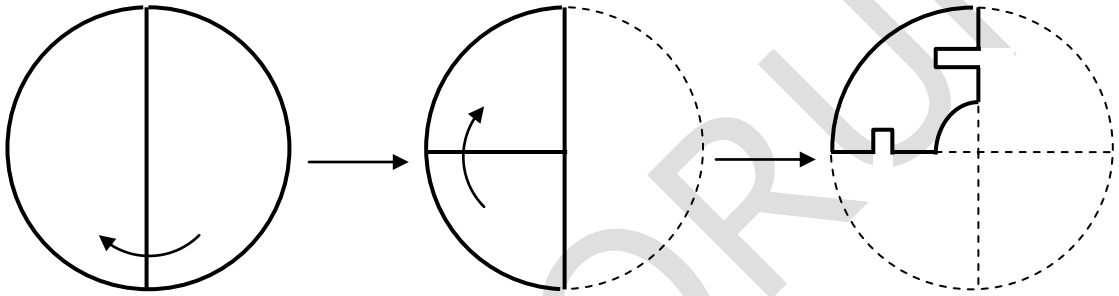
8. _____ is to surgery as writer is to _____. **[1-Mark, MCQ]**

Which one of the following options maintains a similar logical relation in the above sentence?

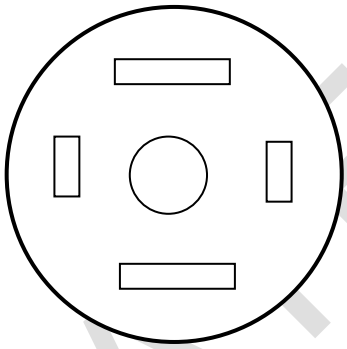
(A) Doctor, book
(B) Plan, outline
(C) Medicine, grammar
(D) Hospital, library

Key: (A)

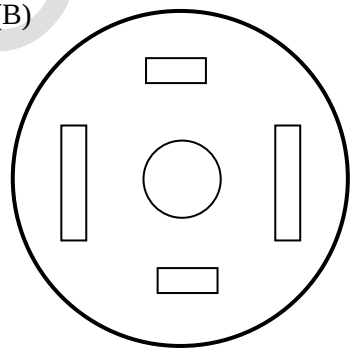
9. A circular sheet of paper is folded along the lines in the directions shown. The paper, after being punched in the final folded state as shown and unfolded in the reverse order of folding, will look like **[1-Mark, MCQ]**



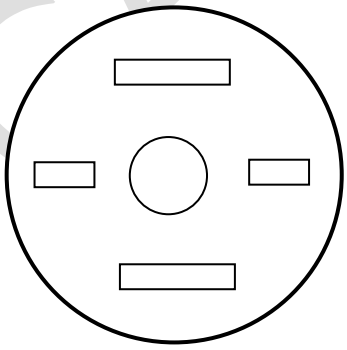
(A)



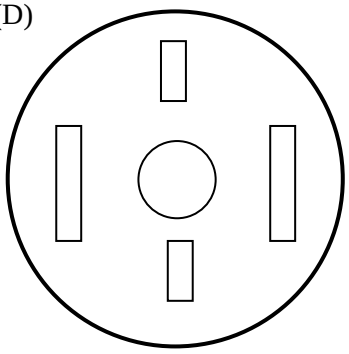
(B)



(C)



(D)



Key: (A)

10. Some people suggest anti-obesity measures (AOM) such as displaying calorie information in restaurant menus, such measures sidestep addressing the core problem that cause obesity: poverty and income inequality.

Which one of the following statements summarizes the passage? **[2-Marks, MCQ]**

(A) AOM are addressing the core problems and are likely to succeed

(B) If obesity reduces, poverty will naturally reduce, since obesity causes poverty

(C) The proposed AOM addresses the core problems that cause obesity

(D) AOM are addressing the problem superficially

Key: (D)

Sol: As AOM are not addressing the core problems, they are superficial.

Superficial: shallow, cursory mean lacking in depth or solidity. superficial implies a concern only with surface aspects or obvious features. a superficial analysis of the problem shallow is more generally derogatory in implying lack of depth in knowledge, reasoning, emotions, or character.

COMPUTER SCIENCE ENGINEERING

1. Let G be a group of order 6, and H be a subgroup of G such that $1<|H|<6$. Which one of the following options is correct? **[2-Marks, MCQ]**

(A) Both G and H are always cyclic

(B) G is always cyclic, but H may not be cyclic

(C) G may not be cyclic, but H is always cyclic

(D) Both G and H may not be cyclic

Key: (C)

Sol: For any element g in any group G, one can form the subgroup of all integer powers ⟨g⟩ = {g^k | k ∈ Z}, called the cyclic subgroup of g.

The order of g is the number of elements in ⟨g⟩; that is, the order of an element is equal to the order of its cyclic subgroup.

A cyclic group is a group which is equal to one of its cyclic subgroups: G = ⟨g⟩ for some element g, called a generator.

(Lagrange's theorem) Let G be a finite group and H ⊂ G a subgroup of G. Then |H| divides |G|.

We know that If G is a finite group with |G| prime, then G is cyclic.

Proof:

Let p = |G|. Since p ≥ 2, there is an element g ∈ G with g ≠ e. Consider the subgroup <g>⊂ G generated by g. We have | <g> | ≥ 2 since both e, g ∈<g>. So by Lagrange's theorem | <g> | = p. Thus <g> = G, and so, by definition, G is cyclic as claimed.

Classification of Groups of Order n ≤ 3 :

n=1: The trivial group <e> is the only group with 1 element.

n=2,3 : These orders are prime, so Lagrange implies that any such group is cyclic.

Given that G has order 6, and H is subgroup of G so, H has order either 1 or 2 or 3 or 6 But it is given that 1 < |H| < 6, So, order of H could be either 2 or 3, so H is cyclic.

A group of order 6 may or may not be cyclic.

2. The following relation records the age of 500 employees of a company, where empNo(indicating the employee number) is the key:

$$\text{empAge}(\underline{\text{empNo}}, \text{age})$$

Consider the following relational algebra expression:

$$\Pi_{\text{emp No}}\left(\text{emp Age} \bowtie_{(\text{age}>\text{age1})} \rho_{\text{empNo1,age1}}\left(\text{emp Age}\right)\right)$$

What does the above expression generate? **[2-Marks, MCQ]**

(A) Employee numbers of only those employees whose age is the maximum

(B) Employee numbers of only those employees whose age is more than the age of exactly one other employee

(C) Employee numbers of all employees whose age is the minimum

(D) Employee numbers of all employees whose age is not the minimum.

Key: (D)

Sol: Rename operation is used here inside the given query which is Renaming the attributes in intermediate result.

So, In the given query, We have two snapshots of the table empAge :

One is empAge(empNo, age)

Another is empAge(empNo1, age1)

Now, we are performing Conditional Join operation on both above snapshots, where condition is "age > age1".

Note that the conditional join operation "logically" works as follows :

First it will do Cross product of both snapshots, then it will select those records/tuples which satisfy the condition "age > age1".

So, the inner query will give us a intermediate result which has the following schema, let me call it M :

M (empNo, age, empNo1, age1)

And in the above intermediate result M, we have those tuples where "age" value is greater than "age1" value.

So, we have those employee numbers "empNo" whose age is greater than "some" employee.

Also, we have those employee numbers "empNo1" whose age is less than "some" employee.

Finally, we are applying Projection operation on the M which will project the attribute "empNo".

So, we have those employee numbers "empNo" whose age is greater than "some" employee. So, Option D is correct.

PS : Note that if we project "empNo1" then we have those employee numbers "empNo1" whose age is less than "some" employee.

3. Assume that a 12-bit Hamming codeword consisting of 8-bit data and 4 check bits is $d_8d_7d_6d_5c_8d_4d_3d_2c_4d_1c_2c_1$, where the data bits and the check bits are given in the following tables:

Data bits							
d_8	d_7	d_6	d_5	d_4	d_3	d_2	d_1
1	1	0	x	0	1	0	1

Check bits			
c_8	c_4	c_2	c_1
y	0	1	0

Which one of the following choices gives the correct values of x and y? **[2-Marks, MCQ]**

(A) x is 0 and y is 0 (B) x is 1 and y is 1

(C) x is 1 and y is 0 (D) x is 0 and y is 1

Key: (A)

Sol:

d_8	d_7	d_6	d_5	c_8	d_4	d_3	d_2	c_4	d_1	c_2	c_1
1	1	0	x	y	0	1	0	0	1	1	0

P1=0+l+0 + 0 + x+1; x = 0 even

P_2 =1 + 1 + 1+ 0 + 0+1 = even

P_4 = 0+0+ 1 + 0+ 1 even

P_8 = y + x + 0+l + l =0

x=0 and y =0

4. Consider the following instruction sequence where registers R1, R2 and R3 are general purpose and MEMORY[X] denotes the content at the memory location X.

Instruction	Semantics	Instruction Size(bytes)
Mov R1,(5000)	R1 ← MEMORY[5000]	4
Mov R2,(R3)	R2 ← MEMORY[R3]	4
ADD R2,R1	R2 ← R1 + R2	2
MOV (R3),R2	MEMORY[R3] ← R2	4
INC R3	R3 ← R3 + 1	2
DEC R1	R1 ← R1 − 1	2
BNZ 1004	Branch if not zero to the given absolute address	2
HALT	Stop	1

Assume that the content of the memory location 5000 is 10, and the content of the register R3 is 3000. The content of each of the memory location from 3000 to 3010 is 50. The instruction sequence starts from the memory location 1000. All the numbers are in decimal format. Assume that the memory is byte addressable.

After the execution of the program, the content of memory location 3010 is _____. **[2-Marks, NAT]**

Key: (50)

Sol: In line #1, we are assigning value 10 to R1.

So, R1 will go from 10 to 0. But the program from line#2 to line#7 will only execute 10 times, when R1 is going from 10 to 1. When R1 becomes 0, we come out of this loop and Halt.

The given program will modify the values of Memory location from 3000 to 3009 only. So, Memory location 3010 will have value 50, unchanged, at the end.

M[3000] = 60

M[3001] = 59

M[3002] = 58

And so on

M[3009] = 51

And

M[3010] = 50

5. An articulation point in a connected graph is a vertex such that removing the vertex and its incident edges disconnected the graph into two or more connected components.

Let T be a DFS tree obtained by doing DFS in a connected undirected graph G.

Which of the following options is/are correct? **[2-Marks, MSQ]**

(A) Root of T can never be an articulation point in G.

(B) If u is an articulation point in G such that x is ancestor of u in T and y is a descendent of u in T, then all paths from x to y in G must pass through u.

(C) A leaf of T can be an articulation point in G

(D) Root of T is an articulation point in G if and only if it has 2 or more children

Key: (D)

Sol: Articulation points can be identified in a single dfs.

The root of the dfs tree is an articulation point iff it has more than one child. If there are two children, there cannot be an edge from one subtree to the other, because non-tree edges are back edges and can only go to an ancestor.

The root of the DFS tree is an articulation if it has two or more children. So option D is true.

6. Consider the following array

23	32	45	69	72	73	89	97

Which algorithm out of the following options uses the least number of comparisons (among the array elements) to sort the above array in ascending order? **[1-Mark, MCQ]**

(A) Insertion sort
(B) Merge sort
(C) Selection sort
(D) Quick sort using the last element as pivot

Key: (A)

Sol: The given array is already sorted in ascending order.

For already sorted array:

Selection sort:

No matter how the data is arranged there would always be comparisons and swaps made and so the time complexity for best, average and worst case is : O(n^2).

In first pass, we need n-1 comparisons (Or n comparisons, depending on the implementation)

In second pass, we need n-2 comparisons (Or n-1 comparisons, depending on the implementation) and so on..

So, The number of comparisons required by a selection sort of n items can be computed by the formula:

$(n-1) + (n-2) + \ldots + 1 = (n)(n-1)/ 2$ Or

Number of selection sort comparisons $= (n+1)(n)/ 2$

Basically, number of comparisons are $\Theta(n^2)$ in all cases.

Insertion Sort:

When elements are sorted, there are no swaps and the correct position of the element in the sorted list is the current index itself. The time complexity is : O(n)

Number of comparisons = n-1

Comparisons in total: $1 + 1 + \ldots + 1 = n - 1 \in \Theta(n)$.

Merge Sort:

We are dividing the list into two no matter if the list is sorted or no. But if the array is sorted, while merging the list there are no swaps merging results into an array itself. Thus, the best, average and worst case time complexity is: O(nlogn)

Number of comparisons, in all cases, will be O(nlogn)

Quick Sort:

The best case is when the elements are in a sorted manner. The best and average case time complexity is :O(nlogn)

Number of comparisons, in best case, will be O(nlogn)

So, answer will be insertion sort. So, answer is option A.

7. For a Turing machine M, $\langle M \rangle$ denotes an encoding of M. Consider the following two languages.

$L_1 = \{\langle M \rangle \mid M \text{ takes more than 2021 steps on all inputs}\}$

$L_2 = \{\langle M \rangle \mid M \text{ takes more than 2021 steps on some input}\}$

Which one of the following options is correct? **[2-Marks, MCQ]**

(A) Both L_1 and L_2 are undecidable

(B) Both L_1 and L_2 are decidable

(C) L_1 is decidable and L_2 is undecidable

(D) L_1 is undecidable and L_2 is decidable

Key: (B)

Sol: L2 is decidable. Run M runs for 2021 steps on each input x of length upto 2021. If M halts before or in exactly 2021 steps on all such inputs then reject M, else accept.

L1 is also decidable. Run M runs for 2021 steps on each input x of length upto 2021. Check if M runs for more than 2021 steps on each input x of length upto 481. If so accept, else reject.

Alternate explanation

(B)

Explanation:

The algorithm exits for it

1. On Given input w
2. Simulate w on TM M
3. If w takes less than 2021 steps output ***NO***
4. If w takes more than 2021, lets say 2022 then out put**YES**

Hence both Yes and No answers are possible for all input w

$L_1 = \{\langle M \rangle \mid M \text{ takes More than 2021 steps on all input}\}$

This problem is the trivial case because for all the string of length 2022 it will always take more than 2021 steps and we don't need to check. The remaining strings are finite and we can check individually whether its taking one extra steps than 2021. This case is also falls under finite computation hence Decidable.

$L_2 = \{\langle M \rangle \mid M \text{ takes more than 2021 steps on some inputs}\}$

Since the same computation and computation is bounded by time and we can use the same algorithm.

8. Consider the following matrix

$$\begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix}$$

The largest eigenvalue of the above matrix is _____ **[2-Marks, NAT]**

Key: (3)

Sol: Characteristic equation is $\begin{vmatrix} -\lambda & 1 & 1 & 1 \\ 1 & -\lambda & 1 & 1 \\ 1 & 1 & -\lambda & 1 \\ 1 & 1 & 1 & -\lambda \end{vmatrix} = 0$

$\Rightarrow (-\lambda+3)(-\lambda-1)^3 = 0$

$\Rightarrow \lambda = -1,-1,-1,3$ are the eigen values of A

$\therefore$ Largest eigen value is 3 $\left(\because \begin{vmatrix} x & y & y & y \\ y & x & y & y \\ y & y & x & y \\ y & y & y & x \end{vmatrix} = (x+3y)(x-y)^3 \right)$

9. There are 6 jobs with distinct difficulty level, and 3 components with distinct processing speeds. Each job is assigned to a computer such that:

- The fastest computer gets the toughest job and the slowest computer gets the easiest job.
- Every computer gets at least one job

The number of ways in which this can be done is _____. **[1-Mark, NAT]**

Key: (65)

Sol: Let jobs be J1 to J6, where J1 is toughest. Let computers be C1,C2,C3 where C1 is the fastest.

So, J1 goes to C1, J6 goes to C3.

Remaining 4 jobs can go to any computer, But computer C2 must get at least one job.

So, Total Cases when Remaining 4 jobs can go to any computer = 3^4

Cases when computer C2 is Not assigned any job = 2^4

Cases when every computer gets at least one job = 81 - 16 = 65

10. Let the representation of a number in base 3 be 210. What is the hexadecimal representation of the number? **[1-Mark, MCQ]**

(A) 528 (B) 21 (C) 15 (D) D2

Key: (C)

Sol: It is given that $(210)_3 = (N)_{16}$, we need to obtain value of N.

$(210)_3 = \left[(2\times 3^2) + (1\times 3^1) + (0\times 3^0) = (21)_{10} = (15)_{16} \right]$

So $(210)_3 = (15)_{16}$ i.e., N=15

11. A relation R is said to be circular if aRb and bRc together imply cRa. Which of the following options is/are correct? **[2-Marks, MSQ]**

(A) If a relation S is reflexive and circular, then S is an equivalence relation.

(B) If a relation S is circular and symmetric, then S is an equivalence relation.

(C) If a relation S is reflexive and symmetric, then S is an equivalence relation.

(D) If a relation S is transitive and circular, then S is an equivalence relation.

Key: (A)

Sol: Option B is false. For counter example, take a set A = {1,2,3}, define relation R on A as follows: R = { (1,1) }, R is symmetric and circular but not equivalence relation.

Option C is false. For counter example, take a set A = {1,2,3}, define relation R on A as follows: R = { (1,1), (2,2),(3,3), (1,2),(2,1), (1,3),(3,1) }, R is symmetric and reflexive but not transitive so not equivalence relation.

Option D is false. For counter example, take a set A = {1,2,3}, define relation R on A as follows: R = { (1,1) }, R is transitive and circular but not equivalence relation.

If R is reflexive and circular then it is symmetric :

Assume xRy. Since R is reflexive, we have yRy. Since R is circular, so, xRy, yRy imply yRx, so, R is symmetric.

If R is reflexive and circular then it is transitive because assume xRy, yRz. Since R is circular, so, zRx, and since R is symmetric so xRz so R is transitive.

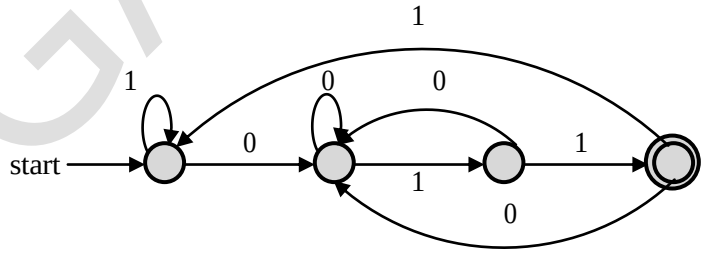
So, option A is correct.

12. Consider the following language.

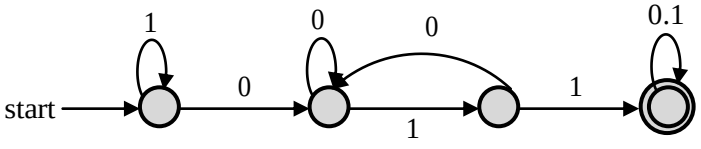
$$L = \{w \in \{0,1\}^* \mid w \text{ ends with the substring } 011\}$$

Which one of the following deterministic finite automata accepts L? **[2-Marks, MCQ]**

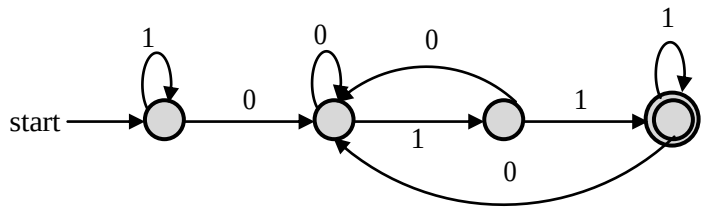
(A)



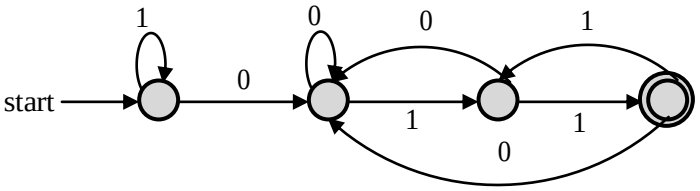
(B)



(C)

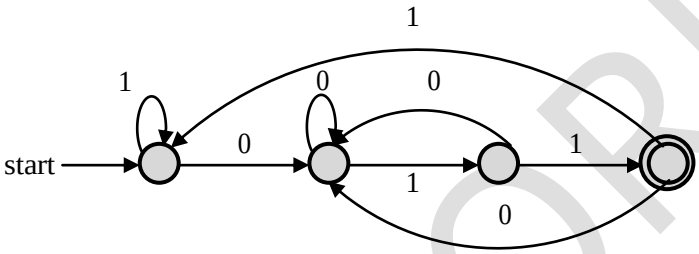


(D)



Key: (A)

Sol:



Ending pattern required n+1 states where n is length of the string, in this case 3 and at least on input goes out of the final state.

Here input 1 from the final state goes to initial state which remember all 1's

And input 0 goes to second state which remember last alphabet as 0

13. Consider the following ANSI C function

```
int SimpleFunction(int Y[], int n, int x)
{
Int total = Y[], loopIndex;
For (loopIndex = 1; loopIndex<=n-1; loopIndex++)
    total = x * total Y[loopIndex];
return total;
}
```

Let Z be an array of 10 elements with Z[i] = 1 for all I such that $0 \le i \le 9$. The value returned by simpleFunction (Z, 10, 2) is _____. **[2-Marks, NAT]**

Key: (1023)

Sol: x = 2 ; every element of array Z is 1.

So, In every iteration of for loop, we are making

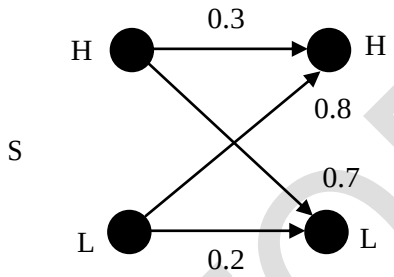
Total = 2*total + 1

So, in ith iteration, total will become 2^{i+1} -1.

So, after last iteration i.e. 9th iteration, total = 1023. S0, answer is 1023.

14. A sender(S) transmits a signal, which can be one of the two kinds. H and L with probabilities 0.1 and 0.9 respectively, to a receiver (R)

In the graph below, the weight of edge (u, v) is the probability of receiving v and u is transmitted, where $u, v \in \{H, L\}$. For example, the probability that the received signal is L given the transmitted signal was H, is 0.7



If the received signal is H, the probability that the transmitted signal was H (rounded to 2 decimal places) is _____. **[2-Marks, NAT]**

Key: (0.04)

Sol: P(TH/RH) = P(RH/TH)*P(TH) / (P(RH/TH)*P(TH) + P(RH/TL)*P(TL))

= 0.3 * 0.1 / (0.3 * 0.1 + 0.8 * 0.9)

= 0.03 / (0.03 + 0.72)

= 0.03 / 0.75 = 0.04

P(TH) = Probability that the transmitted signal is H

P(RH) = Probability that the received signal is H

P(TL) = Probability that the transmitted signal is L

15. Which of the following standard C library functions will always invoke a system call when executed from a single-threaded process in a UNIX/Linux operating system? **[1-Mark, MSQ]**

(A) sleep (B) malloc (C) strlen (D) exit

Key: (A) and (D)

Sol: Sleep and exit uses a system call that executed from a single thread process.

Types of library functions

Library functions can be of two types :

Functions which do not call any system call.

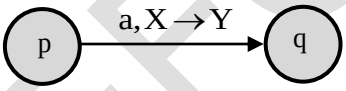
Functions that make a system call.

There are library functions that do not make any system call. For example, the string manipulation functions like strlen() etc fall under this category. Also, there are library functions that further make system calls, for example the fopen() function which a standard library function but internally uses the open() system call.

The function call malloc() is a library function call that further uses the brk() or sbrk() system call for memory allocation. malloc is a function defined in standard C library and it does not always invoke the system call. When a process is created, certain amount of heap memory is already allocated to it, when required to expand or shrink that memory, it internally uses sbrk/brk system call on Unix/Linux.

The Correct answer is A,D.

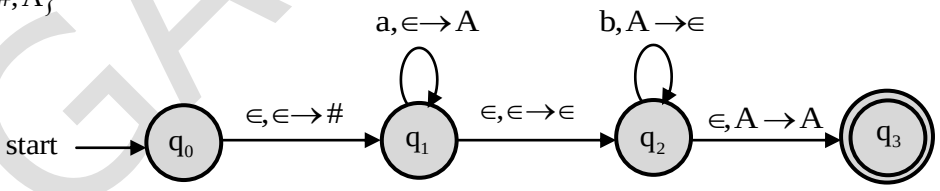
16. In a pushdown automaton $P=(Q,\Sigma,\Gamma,\delta,q_0,F)$, a transition of the form,



where $p,q \in Q$, $a \in \Sigma \cup \{\in\}$, and $X,Y \in \Gamma \{\in\}$, represents

$(q,Y) \in \delta(p,a,X)$

Consider the following pushdown automaton over the input alphabet $\Sigma=\{a,b\}$ and stack alphabet $\Gamma=\{\#,A\}$



The number of strings of length 100 accepted by the above pushdown automaton is _____

[2-Marks, NAT]

Key: (50)

Sol: The give PDA accepts language { $a^n b^m$ | n > m }

Now, number of strings in this language whose length is <= 100 :

When #b = 0, then #a = 100 ; So, one such string.

When #b = 1, then #a = 99 ; So, one such string.

When #b = 2, then #a = 98 ; So, one such string.

And so on…

When #b = 49, then #a = 51 ; So, one such string.

So, total 50 strings.

17. Consider the following grammar (that admits a series of declaration, followed by expression) and the associated syntax directed translation (SDT) actions, given as pseudo-code:

$P \rightarrow D^* E^*$

$D \rightarrow$ int ID {record that ID.lexeme is of type int}

$D \rightarrow$ boo1 ID {record that ID.lexemeis of type boo1}

$E \rightarrow E_1+E_2$ {check that E_1.type = E_2.type =int; set E.type:=int}

$E \rightarrow !E_1$ {check that E_1.type = boo1; set E.type:=boo1}

$E \rightarrow$ ID{set E.type:=int}

With respect to the above grammar, which one of the following choices is correct? **[2-Marks, MCQ]**

(A) The actions will lead to an infinite loop

(B) The actions can be used to type-check syntactically correct Boolean variable declaration and Boolean expression

(C) The actions can be used to type-check syntactically correct integer variable declaration and integer expressions.

(D) The actions can be used to correctly type-check any syntactically correct program.

Key: (C)

Sol: The given syntax directed translation does type checking and also it syntactically checks integer expressions becaue the last statement set the type to int.

18. A binary search tree T contains n distinct elements. What is the time complexity of picking an element in T that is smaller than the maximum element in T? **[1-Mark, MCQ]**

(A) $\Theta(1)$ (B) $\Theta(\log n)$ (C) $\Theta(n \log n)$ (D) $\Theta(n)$

Key: (A)

Sol: If our data structure contains n distinct elements then :

In all the standard data structures that we know/study about, If we want to pick/find an element which is Not maximum (smaller than maximum) then time complexity will be $\Theta(1)$ because we only need to

compare any two elements. Take any two elements that you can access in constant time, compare them and return smaller of those two elements.

PS:

By "standard data structures that we know/study about" I mean the following :

Binary tree, Binary search tree, AVL tree, sorted or unsorted array, linked lists, arrays, stacks, queues, hash tables, heaps etc.

19. Let $r_i(z)$ and $w_i(z)$ denote read and write operations respectively on a data item z by a transaction T_i. Consider the following two schedules. **[2-Marks, MCQ]**

$\mathbf{S_1}$: $r_1(x)r_1(y)r_2(x)r_2(y)w_2(y)w_1(x)$

$\mathbf{S_2}$: $r_1(x)r_2(x)r_2(y)w_2(y)r_1(y)w_1(x)$

Which one of the following options is correct?

(A) Both S_1 and S_2 are conflict serializable

(B) S_1 is not conflict serializable, and S_2 is conflict serializable

(C) S_1 is conflict serializable, and S_2 is not conflict serializable

(D) Neither $S_1$and S_2 are conflict serializable.

Key: (B)

Sol: S1 is Not conflict serializable because :

Due to r1(y) ---> w2(y), we get edge from T1 to T2 in precedence graph of S1.

Due to r2(x) ---> w1(x), we get edge from T2 to T1 in precedence graph of S1.

So, we have cycle in precedence graph, hence, not conflict serializable.

S2 is conflict serializable because we only have edge from T2 to T1 in the precedence graph of S2.

20. Consider the following recurrence relation

$$T(n)=\begin{cases}T(n/2)+T(2n/5)+7n & \text{if } n>0\\ 1 & \text{if } n=0\end{cases}$$

Which one of the following options is correct? **[2-Marks, MCQ]**

(A) $T(n)=\Theta(n\log n)$

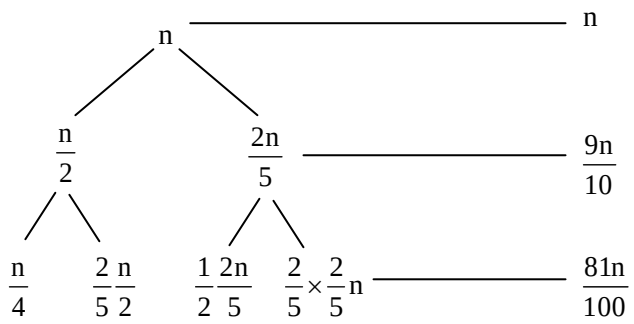
(B) $T(n)=\Theta\left((\log n)^{5/2}\right)$

(C) $T(n)=\Theta\left(n^{5/2}\right)$

(D) $T(n)=\Theta(n)$

Key: (D)

Sol: $T(n)=T\left(\frac{n}{2}\right)+T\left(\frac{2n}{5}\right)+7n$



$$n+\frac{9}{10}n+\left(\frac{9}{10}\right)^2 n+\ldots \log n \text{ times}$$

$$\therefore \quad n\left[1+\frac{9}{10}+\left(\frac{9}{10}\right)^2+\ldots \log n \text{ times}\right]$$

$$=\Theta(n)$$

21. Consider the following pseudocode, where S is a semaphore initialized to 5 in line #2 and counter is a shared variable initialized to 0 in line #1. Assume that the increment operation in line #7 is not atomic.

```
1.  int counter = 0;
2.  Semaphore S = int (5);
3.  void parop (void)
4.  {
5.  wait (S);
6.  wait (S);
7.  counter ++;
8.  signal (S);
9.  signal (S);
10. }
```

If we threads execute the function parop concurrently, which of the following program behavior(s) is/are possible? **[2-Marks, MSQ]**

(A) There is a deadlock involving all the threads.

(B) The value of counter is 5 after all the threads successfully complete the execution of parop

(C) The value of counter is 1 after all the thread successfully complete the execution of parop

(D) The value of counter is 0 after all the threads successfully complete the execution of parop

Key: (A,B,C)

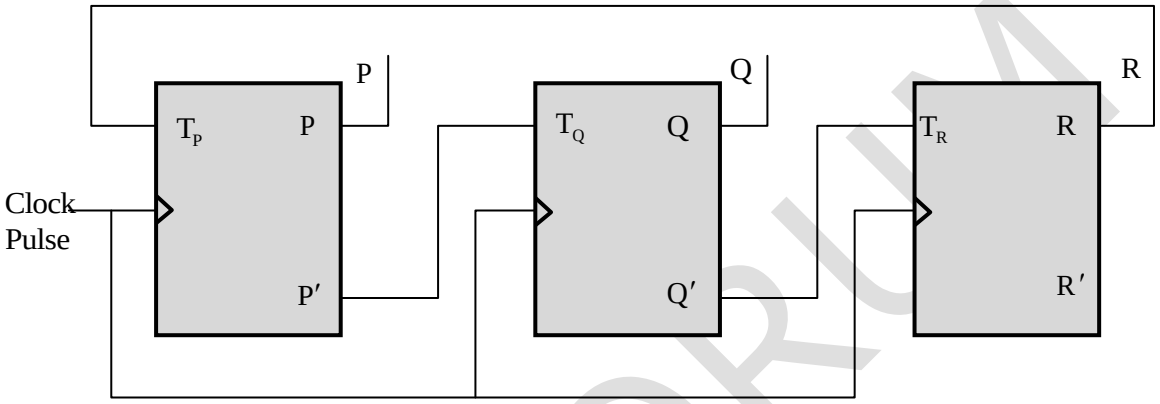
Sol: Deadlock is possible if all the processes execute Line#5, then in Line#6, all processes will get into deadlock.

Counter = 5 is possible if all processes execute the given program in serial manner, one after other.

Counter = 1 is possible if process P1 reads counter value, but not changes it, and all other processes execute complete program one after another in serial manner, then at last P1 makes counter = 1.

Counter = 0 is Not possible after successful execution of all 5 processes.

22. Consider a 3-bit counter, designed using T flip-flops, as shown below:



Assuming the initial state of the counter given by PQR as 000, what are the next three states?

[2-Marks, MCQ]

(A) 011, 101, 111 (B) 001, 010,000

(C) 011, 101, 000 (D) 001, 010, 111

Key: (C)

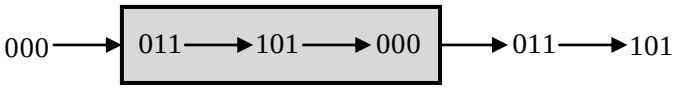
Sol: In the given counter circuit we need to obtain the counting states for 3 clock cycles.

Present state			Flip flops inputs			Next state		
			(R)	($\bar{P}$)	($\bar{Q}$)			
P	Q	R	T_P	T_Q	T_R	P^+	Q^+	R^+
0	0	0	0	1	1	0	1	1
0	0	1	1	1	1	1	1	0
0	1	0	0	1	0	0	0	0
0	1	1	1	1	0	1	0	1
1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	0	0	0
1	1	0	0	0	0	1	1	0
1	1	1	1	0	0	0	1	1

By referring the given circuit flip flop input expression are written. Using Flip flop input (T) and present states, and state table of TFI next state are obtained.

So the next state are obtained.

So the counting pattern is



23. Let (M) denote an encoding of an automation M, suppose that $\Sigma = \{0,1\}$. Which of the following languages is/are NOT recursive? **[1-Mark, MSQ]**

(A) $L = \{\langle M \rangle \mid M \text{ is a DFA such that } L(M) = \phi\}$

(B) $L = \{\langle M \rangle \mid M \text{ is a PDA such that } L(M) = \phi\}$

(C) $L = \{\langle M \rangle \mid M \text{ is a DFA such that } L(M) = \Sigma^*\}$

(D) $L = \{\langle M \rangle \mid M \text{ is a PDA such that } L(M) = \Sigma^*\}$

Key: (D)

Sol: (A) is $L = \{\langle M \rangle \mid M$ is a DFA such that L(M) is $\Sigma^*\}$ is a trivial problem for DFA and **DECIDABLE** and **Recursive**.

(B) is **UNDECIDABLE** and **NOT Recursive**; we can't check whether $L(G) = \Sigma^*$ or not but rather we can check complemented of L(G) is $\varnothing$. Since context free language are not closed under complement operation $\overline{L(G)}$ may be language accepted by Turing Machine and we can't check emptiness for Turing machine.

(C) is **DECIDABLE** and **Recursive**; The language accepted we can check for usefulness of start symbol. If the start symbol is useful then L(G) non empty otherwise L(G) is empty

Option (D) is **DECIDABLE and recursive**; emptiness of the finite state machine can be checked by reachability of the final state from initial state in transition graph. If the final state is reachable then non empty otherwise empty.

24. Consider two hosts P and Q connected through a router R. The maximum transfer unit (MTU) value of the link between P and R is 1500 bytes, and between R and is 820 bytes.

A TCP segment of size 1400 bytes was transferred from P to Q through R, with IP identification value as 0×1234.

Assume that the IP header size is 20 bytes. Further the packet is allowed to be fragmented, i.e., Don't Fragment (DF) flag in the IP head is not set by P.

Which of the following statements is/are correct? **[2-Marks, MSQ]**

(A) If the second fragment is lost, P is required to resend the whole TCP segment

(B) TCP destination port can be determined by analyzing only the second fragment

(C) If the second fragment is lost, R will resend the fragment with the IP identification

(D) Two fragments are created at R and the IP datagram size carrying the second fragment is 620 bytes

Key: (A,D)

Sol: If the second fragment is lost P is required to resend the whole TCP segment. The second fragment size at R is 1400 - 800 + 20(header size) = 620 bytes

25. Consider the sliding window flow-control protocol operating between a sender and a receiver over a full-duplex free link. Assume the following:

- The time take for processing the data frame by the receiver is negligible.
- The time taken for processing the acknowledgement frame by the sender is negligib**le.**
- The sender has infinite number of frames available for transmission
- The size of the data frame is 2,000 bits are the size of the acknowledgement frame is 10 bits.
- The link data rate in each direction is 1 Mbps (10^6 bits per second)
- One way propagation delay of the link is 100 milliseconds

The minimum value of the sender's window size in terms of the number of frames, (rounded to the nearest integer) needed to achieve a link utilization of 50% is _____. **[2-Marks, NAT]**

Key: (50)

Sol: Transmission delay = 2 msec,

Ack Transmission delay = 0.01 msec, p

propagation delay = 100 msec

$$\eta = \frac{W}{1+2a}; a = \frac{\text{Propagation delay}}{\text{Transmission Delay}}$$

$W = 202.01 / 4$

$W = 50.5025$

So. Window size = 50

26. Consider the following context-free grammar where the set of terminals is {a, b, c, d, f}

$S \rightarrow daT \mid Rf$

$T \rightarrow aS \mid baT \mid \in$

$R \rightarrow caTR \mid \in$

The following is a partially-filled LL(1) parsing table.

	a	b	c	d	f	$
S			(1)	$S \rightarrow daT$	2	
T	$T \rightarrow aS$	$T \rightarrow baT$	(3)		$T \rightarrow \in$	(4)
R			$R \rightarrow caTR$		$R \rightarrow \in$	

Which one of the following choices represent the correct combination for the numbered cells in the paring table ("blank" denotes that the corresponding cell is empty)? **[2-Marks, MCQ]**

(A) (1) $S \rightarrow Rf$ (2) blank (3) blank (4) $T \rightarrow \in$

(B) (1) blank (2) $S \rightarrow Rf$ (3) blank (4) blank

(C) (1) blank (2) $S \rightarrow Rf$ (3) $T \rightarrow \in$ (4) $T \rightarrow \in$

(D) (1) $S \rightarrow Rf$ (2) $S \rightarrow Rf$ (3) $T \rightarrow \in$ (4) $T \rightarrow \in$

Key: (D)

Sol: The production $S \rightarrow Rf$ will go in the row corresponding to S below first(Rf).

First(Rf) = { c,f }

The production $T \rightarrow \epsilon$ will go in the row corresponding to T below Follow(T).

Follow(T) = { $, c, f }

Alternative explanation

	a	b	c	d	f	$
S			$S \rightarrow Rf$	$S \rightarrow daT$	$S \rightarrow Rf$	
T	$T \rightarrow aS$	$T \rightarrow baT$	$T \rightarrow \varepsilon$		$T \rightarrow \varepsilon$	$T \rightarrow \varepsilon$
R			$R \rightarrow caTR$		$R \rightarrow \varepsilon$	

Calculation of blank space 1 and 2

$S \rightarrow Rf$ will be the entry

Hear this entry will go to first of R which is $\{c,\varepsilon\}$

In c column we will put the entry $S \rightarrow Rf$ and for epsilon we will consider the next symbol which is f

For the black space 3 and 4

$T \rightarrow \varepsilon$

We will consider follow (T) which is follow(S) which is $

Follow(T) will be also first(R) which is ***c***

And if R derives ε then we will also consider Follow of R which is f

27. A relation r(A, B) in a relational database has 1200 tuples. The attribute A has integer values ranging from 6 to 20, and the attribute B has integer values ranging from 1 to 20. Assume that the attributes A and B are independently distributed.

The estimated number of tuples in the output of $\sigma_{(A>10)\vee(B=18)}(r)$ is _____. **[1-Mark, NAT]**

Key: (820)

Sol: Probability (A > 10)= $\frac{10}{15}$

Probability (B = 18)= $\frac{1}{20}$

Probability (A> 10 and B = 18) = $\frac{10}{15}\times\frac{1}{20}$

(Because both are independent events)

Probability (A> 10 or B = 18)= Probability(A>10)+Probability(B=18)- Probability(A> 10 and B = 18)

$=\frac{10}{15}+\frac{1}{20}-\frac{10}{15}\times\frac{1}{20}=\frac{41}{60}$

The estimated number of tuples

$1200\times\frac{41}{60}=820$

28. Consider the following representation of a number in IEEE 754 single-precision floating point format with a bias of 127.

S:1 E: 10000001 F: 11110000000000000000000

Here S, E and F denote the sign, exponent and fraction components of the floating point representation

The decimal value corresponding to the above representation (rounded to 2 decimal places) is _____.

[1-Mark, NAT]

Key: (-7.75)

Sol: E = 1000 000 1 = 129

So, actual exponent = 129 - bias = 129 - 127 = 2

$-1 * 2^2 * 1.111100000\ldots00$

= - 111.110000..00

= - 7.75

Alternative Method:

It is given that IEEE 754 format with bias 127

S = 1 $\Rightarrow$ Number is negative

$E = 10000001 \Rightarrow 2^7 + 2^6 = 128 + 1 = 129$

$F = 1111$

Biased exponent: 129

Exponent: Biased exponent – 127 = 129 – 127 = 2

Binary number: -1.1111×2^2

$= -(111.11)_2$

$= -\left[(1\times 2^2) + (1\times 2^1) + (1\times 2^0) + (1\times 2^{-1}) + (1\times 2^{-2})\right]$

$= [4 + 2 + 1 + 0.5 + 0.25]$

$= -7.75$

29. Suppose that L_1 is a regular language and L_2 is a context-language. Which one of the following languages is NOT necessarily context-free? **[1-Mark, MCQ]**

(A) $L_1 \cap L_2$ (B) $L_1 \cup L_2$ (C) $L_1 - L_2$ (D) $L_1 . L_2$

Key: (C)

Sol: $L1 - L2 = L1 \cap \overline{L2}$

We know That Context free language is not closed under complement hence $\overline{L2}$ may be the non-Context free language.

$L1 \cap \overline{L2}$ may be a non-context free language.

30. Consider the following expression

$$\lim_{z\to -3} \frac{\sqrt{2x+22}-4}{x+3}$$

The value of the above expression (rounded to 2 decimal places) is _____. **[1-Mark, NAT]**

Key: (0.25)

Sol: $\lim\limits_{x\to -3}\dfrac{\sqrt{2x-22}-4}{x+3}$ is $\dfrac{0}{0}$ form

$$=\lim_{x\to -3}\frac{2\times\dfrac{1}{2\sqrt{2x+22}}-0}{1+0}\left(\text{Using L}-\text{Hospital's rule and }\frac{d}{dx}\left(\sqrt{x}\right)=\frac{1}{2\sqrt{x}}\right)$$

$$=\frac{1}{\sqrt{16}}=\frac{1}{4}=0.25$$

31. Suppose a database system crashes again while recovering from a previous crash.

Assume check pointing is not done by the database either during the transactions or during recovery.

Which of the following statements is/are correct? **[1-Mark, MSQ]**

(A) The system cannot recover any further.

(B) All the transactions that are already undone and redone will not be recovered again.

(C) The same undo and redo list will be used while recovering again.

(D) The database will become inconsistent

Key: (C)

Sol: The same undo and redo list will be used while recovering again.

32. Consider the following statements.

S_1 : Every SLR(1) grammar is unambiguous but there are certain unambiguous grammars that are not SLR(1).

S_2 : For any context-free grammar, there is a parser that takes at most $O(n^3)$ time to parse a string of length n.

Which one of the following options is correct? **[1-Mark, MCQ]**

(A) S_1 is true and S_2 is true

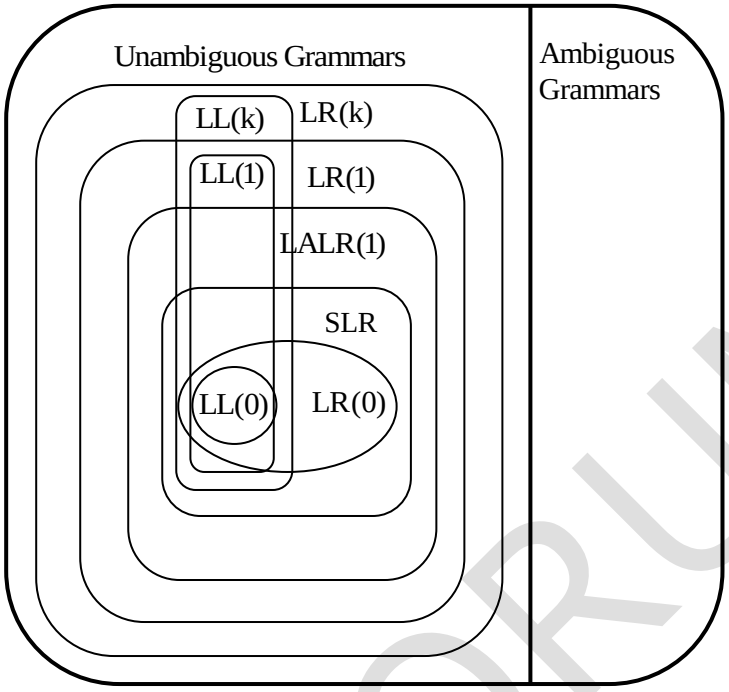
(B) S_1 is false and S_2 is false

(C) S_1 is false and S_2 is true

(D) S_1 is true and S_2 is false

Key: (A)

Sol: Look at the diagram



S1 is TRUE; If you look at the above diagram only unambiguous grammar are parsed by SLR and outside of SLR there are many grammar not parable by SLR

S2 is also TRUE, The **complexity** of brute-force-search **parsing** with backtracking is **O**($\mathbf{n^3}$) because, after each of the n words is accepted, the whole **O**(n) process may have to be done over from the beginning.

33. Consider the following statements.

S_1 : The sequence of procedure calls corresponds to a preorder traversal of the activation tree.

S_2 : The sequence of procedure returns corresponds to a postorder traversal of the activation tree.

Which one of the following options is correct? **[1-Mark, MCQ]**

(A) S_1 is false and S_2 is fal**se.**

(B) S_1 is true and S_2 is false

(C) S_1 is false and S_2 is true.

(D) S_1 is true and S_2 is true

Key: (D)

Sol: We can make the following observations about these procedure calls.

If an activation of p calls q, then that activation of p terminates no earlier than the activation of q.

The order of activations (procedure calls) corresponds to a preorder traversal of the call tree.

The order of de-activations (procedure returns) corresponds to postorder traversal of the call tree.

If execution is currently in an activation corresponding to a node N of the activation tree, then the activations that are currently live are those corresponding to N and its ancestors in the tree. These live activations were called in the order given by the root-to-N path in the tree, and the returns will occur in the reverse order.

The use of a run-time stack is enabled by several useful relationships between the **activation tree** and the behavior of the program:

The sequence of procedure calls corresponds to a preorder traversal of the activation tree.

The sequence of returns corresponds to a postorder traversal of the activation tree.

Suppose that control lies within a particular activation of some procedure, corresponding to a node N of the activation tree. Then the activations that are currently open (live) are those that correspond to node N and its ancestors. The order in which these activations were called is the order in which they appear along the path to N , starting at the root, and they will return in the reverse of that order.

34. Consider the following sequence of operations on an empty stack.

```
push (54); push (52); pop (); push (55); push (62); s = pop ();
```

Consider the following sequence of operations on an empty queue.

enqueue (21), enqueue (24), deque (); enqueue (28); enqueue (32); q = dequeue ();

The value of $s+q$ is _____. **[1-Mark, NAT]**

Key: (86)

Sol: Stack is LIFO, so, s = 62

Queue is FIFO, so, q = 24

s +q = 86

35. Consider a linear list based directory implementation in a file system. Each directory is a list of nodes, where each node contains the file name along with the file metadata, such as the list of pointers to the data blocks. Consider a given directory foo. **[1-Mark, MSQ]**

Which of the following operations will necessarily require a full scan of foo for successful completion?

(A) Opening of an existing file in foo

(B) Creation of a new file in foo

(C) Renaming of an existing file in foo

(D) Deletion of an existing file from foo

Key: (B, C)

Sol: While creating new file we have to check whether same name file exist or not , so we always need full scan for this

Renaming a file:

While renaming a file we have to check whether file with same name as newly named file exist or not , so we always need full scan for this.

Creating a new file

While creating a new file, we need to insure the file name deos not exits.Full scanning of the filw will insure this.

.

36. Let G = (V, E) be an undirected unweighted connected graph. The diameter of G is defined as:

$$\text{diam}(G) = \max_{u,v \in V} \{\text{the length of shortest path between u and v}\}$$

Let M be the adjacency matrix of G.

Defined graph G_2 on the same set of vertices with adjacency matrix N, where

$$N_0 = \begin{cases} 1 & \text{if } M_{ij} > 0 \text{ or } P_{ij} > 0, \text{ where } P = M^2 \\ 0 & \text{otherwise} \end{cases}$$

Which one of the following statements is true? **[2-Marks, MCQ]**

(A) $\lceil \text{diam}(G)/2 \rceil < \text{diam}(G_2) < \text{diam}(G)$ (B) $\text{diam}(G_2) \le \lceil \text{diam}(G)/2 \rceil$

(C) $\text{diam}(G_2) = \text{diam}(G)$ (D) $\text{diam}(G) < \text{diam}(G_2) \le 2\,\text{diam}(G)$

Key: (B)

Sol: If M is adjacency matrix of G then When we M^2 + M , we get G2 in which all the edges of G are already there, additionally we have edges between those vertices of G which have a path of length less than or equal to 2 between them. So, Diam(G2) will be half the diam(G), option B is correct.

37. In an undirected connected planner graph G, there are eight vertices and five faces.

The number of edges in G is _____. **[1-Mark, NAT]**

Key: (11)

Sol: By Euler formula for connected planar graph,

f = e-v+2

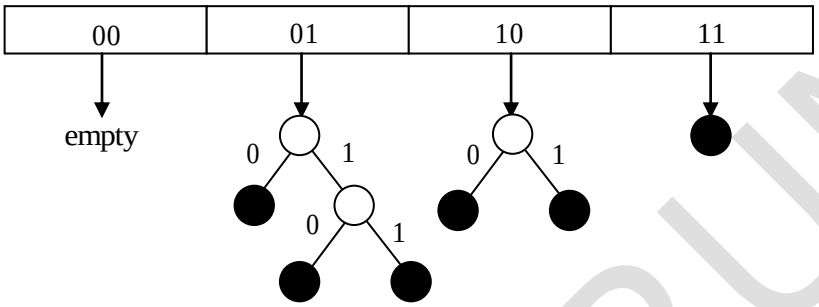
So, e =11

38. Consider a dynamic hashing approach for 4-bit integer keys:

1. There is a main has tables of size 4.
2. The 2 lease significant bits of a key is used to index into the main hash table.
3. Initially, the main hash table entries are empty.

4. All keys corresponding to a main has table entry is organized as a binary tree that grows on demand.
5. First, the 3rd least significant bit is used to divide the keys into left and right subtrees.
6. To resolve more collisions, each mode of the binary tree is further sub-divided into left and right subtrees based on the 4th least significant bit.
7. A split is done only if it is needed, i.e., only when there is a collision.

Consider the following state of the hash table.



Which of the following sequence of key insertion can cause the above state of the hash table (assume the keys are in decimal notation)? **[2-Marks, MSQ]**

(A) 5, 9, 4, 13, 10, 7 (B) 9, 5, 10, 6, 7, 1 (C) 10, 9, 6, 7, 5, 13 (D) 9, 5, 13, 6, 10, 14

Key: (C)

Sol: Option A is false because key 4 is 0100 so it will go in the slot 00, which should be empty according to the given diagram.

Option B is false because key 5,9,1 will go in the slot 01, but 1,9 will go on the left side, and 5 on right side, so, false.

Option D is false because key 14,6,10 will go in the slot 10, which should have only two keys according to the given diagram.

So, answer is C.

39. Consider the following three functions.

$f_1 = 10^n \quad f_2 = n^{\log n} \quad f_2 = n^{\sqrt{n}} \quad f$

Which one of the following options arranges the functions in the increasing order of asymptotic growth rate? **[1-Mark, MCQ]**

(A) f_1, f_2, f_3 (B) f_3, f_2, f_1 (C) f_2, f_3, f_1 (D) f_2, f_1, f_3

Key: (C)

Sol: f1 is exponential function, so grows fastest.

Between f2, f3 ; f3 grows faster than f2.

40. Three processes arrive at time zero with CPU bursts of 16, 20 and 10 milliseconds. If the scheduler has prior knowledge about the length of the CPU bursts, the minimum achievable average waiting time for these three processes in a non-preemptive scheduler (rounded to nearest integer) is_____milliseconds.

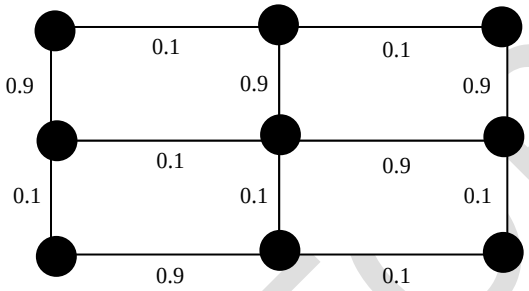
[1-Mark, NAT]

Key: (12)

Sol: Minimum waiting time will be given by SJF algo. So, execution order will be P3,P1, P2. Waiting times of P1,P2,P3 respectively will be 10, 26,0.

So, average waiting time = 12

41. Consider the following undirected graph with edge weights as shown:



The number of minimum-weight spanning trees of the graph is _____. **[1-Mark, NAT]**

Key: (3)

Sol: Apply Kruskal's algorithm. All the edges with weights 0.1 will be in the MST. Now we need to pick one edge out of three candidates of 0.9 weights. So, 3 MST possible.

42. A TCP server application is programmed to listen on port number P on host S. A TCP client is connected to the TCP server over the network.

Consider that while the TCP connection was active, the server machine S crashed and rebooted. Assume that the client does not use the TCP keep alive timer.

Which of the following behaviors is/are possible? **[2-Marks, MSQ]**

(A) The TCP serve application on S can listen on P after reboot

(B) If the client sends a packet after the server reboot, it will receive a FIN segment

(C) If the client was waiting to receiver a packet, it may wait indefinitely

(D) If the client sends a packet after the server reboot, it will receive a RST segment

Key: (A,C,D)

Sol: After server reboots, it doesn't have any information of previous connection, so, client may have to wait indefinitely as client doesn't have keep alive timer. Also, as a general rule, reset (RST) must be sent whenever a segment arrives which apparently is not intended for the current connection. Since, the previous connection got terminated, now server can again listen on P.

43. The lifetime of a component of a certain type is a random variable whose probability density function is exponentially distributed with parameter 2. For a randomly picked component of this type, the probability that its life time exceeds the expected life time (rounded to 2 decimal places) is _____.

[1-Mark, NAT]

Key: (0.37)

Sol: Let X be exponential random variable denote lifetime

$$\Rightarrow f(x)=\begin{cases}\theta e^{-\theta x}, & x \geq 0 \\ 0 & \text{otherwise}\end{cases} \text{ and } \theta = 2 \text{ is parameter}$$

$$\Rightarrow E(x), \text{mean} = \frac{1}{\theta} = 0.5 \text{ is expected life time}$$

$$\therefore \quad \text{Required probability is } P(X > 0.5) = \int_{0.5}^{\infty} f(x)\,dx$$

$$= 2\left(\frac{e^{-2x}}{-2}\right)_{0.5}^{\infty} = e^{-1} - e^{-\infty} = \frac{1}{e} \approx 0.37$$

44. Consider the following two statements.

S_1 : Destination MAC address of an ARP reply is a broadcast address.

S_2 : Destination MAC address of an ARP request is a broadcast address.

Which one of the following choices is correct? **[1-Mark, MCQ]**

(A) S_1 is false and S_2 is true

(B) Both S_1 and S_2 are false

(C) S_1 is true and S_2 is false

(D) Both S_1 and S_2 are true

Key: (A)

Sol: Address Resolution Protocol

If a machine talks to another machine in the same network, it requires its physical or MAC address. But,since the application has given the destination's IP address it requires some mechanism to bind the IP address with its MAC address.This is done through Address Resolution protocol (ARP).IP address of the destination node is broadcast and the destination node informs the source of its MAC address.

Assume broadcast nature of LAN

Broadcast IP address of the destination

Destination replies it with its MAC address.

Source maintains a cache of IP and MAC address bindings

There are four types of arp messages that may be sent by the arp protocol. These are identified by four values in the "operation" field of an arp message. The types of message are:

ARP-Request (Broadcast, source IP address of the requester)

ARP-Reply (Unicast to requester, the target)

45. Let p and q be two propositions. Consider the following two formula in propositional logic.

$S_1 : (\neg p \wedge (p \vee q)) \rightarrow q$

$S_2 : q \rightarrow (\neg p \wedge (p \vee q))$

Which one of the following choices is correct? **[1-Mark, MCQ]**

(A) Neither S_1 nor S_2 is a tautology

(B) S_1 is a tautology but S_2 is not a tautology

(C) Both S_1 and S_2 are tautologies

(D) S_1 is not a tautology but S_2 is a tautology

Key: (B)

Sol: S1:(p' ∧ (p v q)) → q

When q is false, then (p' ∧ (p v q)) cannot become true, so S1 is tautology.

S2:q → (p' ∧ (p v q))

When q is true, still (p' ∧ (p v q)) can become false, so, S2 is not a tautology.

46. Consider the following Boolean expression

$F = (X + Y + Z)(\bar{X} + Y)(\bar{Y} + Z)$

Which of the following Boolean expression is/are equivalent to $\bar{F}$ (complement of F)?

[2-Marks, MSQ]

(A) $X\bar{Y} + Y\bar{Z} + \bar{X}\bar{Y}\bar{Z}$

(B) $(X + \bar{Z})(\bar{Y} + \bar{Z})$

(C) $(\bar{X} + \bar{Y} + \bar{Z})(X + \bar{Y})(Y + \bar{Z})$

(D) $X\bar{Y} + \bar{Z}$

Key: (A,B,D)

Sol: It is given that

$F(x, y, z) = (x + y + z)(\bar{x} + y)(\bar{y} + z)$

We need to obtain equivalent Boolean expression of $\bar{F}$.

$F(x,y,z) = x + \quad y + \quad z \quad \bar{x} + \quad y + \quad - \qquad\qquad -+ \quad \bar{y} \quad +z$

$0 \quad 0 \quad 0 \quad 1 \quad 0 \quad 0 \qquad\qquad 0 \quad 1 \quad 0$

$1 \quad 0 \quad 1 \qquad\qquad 1 \quad 1 \quad 0$

$F(x,y,z) = \pi m(0,2,4,5,6) = \Sigma m(1,3,7)$

$\bar{F}(x,y,z) = \pi(1,3,7) = \Sigma m(0,2,4,5,6)$

Option A:

$\bar{F} = x\bar{y} + yz + \bar{x}\,\bar{y}\,\bar{z} = \Sigma m(0,2,4,5,6) = \pi m(2,3,7)$

$= 100 \quad 010 \quad 000$

$= 101 \quad 110$

So option A is equivalent to $\bar{F}$

Option B:

$\bar{F} = (x + \bar{z})(\bar{y} + \bar{z}) = \pi m(1,3,7) = \Sigma m(0,2,4,5,6)$

$x+$	$-$	$+\bar{z}$	$-$	$+\bar{y}$	$+\bar{z}$
0	0	1	0	1	1
0	1	1	1	1	1

So option B is also equivalent to $\bar{F}$.

Option C:

$\bar{F} = (\bar{x} + \bar{y} + \bar{z})(x + \bar{y})(y + \bar{z}) = \pi m(1,2,3,5,7) = \Sigma m(0,4,6)$

$= (\bar{x} + \bar{y} + \bar{z})(x + \bar{y} -)(- + y + \bar{z})$

$1 \quad 1 \quad 1 \quad 0 \quad 1 \quad 0 \quad 0 \quad 0 \quad 1$

$0 \quad 1 \quad 1 \quad 1 \quad 0 \quad 1$

So option C is not equivalent to $\bar{F}$.

$\bar{F} = x\bar{y} + \bar{z} = \Sigma m(0,2,4,5,6) = \pi(1,3,7)$

x	$\bar{y}$	$-$	$+$	$-$	$-$	$\bar{z}$
1	0	0		0	0	0
1	0	1		0	1	0
				1	0	0
				1	1	0

So option D is also equivalent to $\bar{F}$.

So option A, B, D represent equivalent expression of $\bar{F}$.

47. Let P be an array containing n integers, Lett be the lowest upper bound on the number of comparisons of the array elements, required to find the minimum and maximum values in an arbitrary array of n elements. Which one of the following choices is correct? **[1-Mark, MCQ]**

(A) $t > 2n - 2$

(B) $t > \lceil \log_2(n) \rceil$ and $t \le n$

(C) $t > n$ and $t \le 3\left\lceil \frac{n}{2} \right\rceil$

(D) $t > 3\left\lceil \frac{n}{2} \right\rceil$ and $t \le 2n - 2$

Key: (C)

Sol: To Find the Maximum and Minimum Elements in an array simultaneously, Ceil(n/2) - 2 comparisons are necessary and sufficient in the worst case to find both the maximum and minimum of n numbers.

So, t = Ceil(n/2) - 2

So, option C is correct.

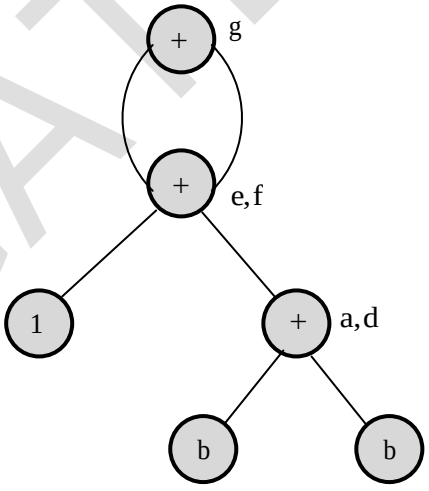
48. Consider the following C code segment:

```
a = b + c;
e = a + 1;
d = b + c;
f = d + 1
g = e + f;
```

In a compiler, this code segment is represented internally as a directed acyclic graph (DAG). The number of nodes in the DAG is _____. **[2-Marks, NAT]**

Key: (6)

Sol:



6 node

49. Consider the two statements:

$\mathbf{S_1}$: There exist random variables X and Y such that

$$\left(E\left[\left(X-E(x)\right)\left(Y-E(Y)\right)\right]\right)^2 > \mathrm{Var}[X]\mathrm{Var}[Y]$$

S_2 : For all random variables X and Y,

$$\mathrm{Cov}[X,Y] = E\left[X-E[X]\middle|Y-E[Y]\right]$$

[2-Marks, MCQ]

(A) Both S_1 and S_2 are false

(B) S_1 is false but S_2 is true

(C) Both S_1 and S_2 are true

(D) S_1 is true but S_2 is false

Key (A)

Sol: We know that $r = \dfrac{\mathrm{cov}(X,Y)}{\sigma_X\sigma_Y}$ is correlation coefficient and $0 < r^2 < 1$

$$\Rightarrow \left(\mathrm{cov}(X,Y)\right)^2 < \sigma_X^2\sigma_Y^2$$

$$\Rightarrow \left(E\left[X-E(X)\right]\right).\left(Y-E(Y)\right)^2 < \mathrm{Var}(X)\mathrm{Var}(Y) \Rightarrow S_1 \text{ is false.}$$

50. Consider the relation $R(P,Q,S,T,X,Y,Z,W)$ with the following functional dependencies.

$$PQ \to X : P \to YX : Q \to Y : Y \to ZW$$

Consider the decomposition of the relations R into the constituent relations according to the following two decompositions schemes.

$\mathbf{D_1}$: $R = \left[(P,Q,S,T);(P,T,X);(Q,Y);(Y,Z,W)\right]$

$\mathbf{D_2}$: $R = \left[(P,Q,S);(T,X);(Q,Y);(Y,Z,W)\right]$

Which one of the following options is correct? **[2-Marks, MCQ]**

(A) D_1 is law lossy decomposition, but D_2 is a lossless decomposition

(B) Both $D_1$and D_2 are lossy decomposition

(C) D_1 is lossless decomposition, but D_2 is a lossy decomposition

(D) Both D_1 and D_2 are lossless decompositions

Key: (C)

Sol: D1 is lossless. (Q,Y) and (Y,W,Z) have common attribute Y which is key in (Y,W,Z), so we can merge them in lossless manner. Now (Q,Y,W,Z)and (P,Q,S,T) have Q in common which is key in (Q,Y,W,Z). Then (Q,Y,W,Z,P,S,T) and (P,T,X) have P,T in common which is key in (P,T,X)

So, D1 is lossless.

D2 is lossy because (T,X) has nothing common with remaining relations.

51. In the context of operating systems, which of the following statements is/are are correct with respect to paging? **[1-Mark, MSQ]**

(A) Page size has no impact on internal fragmentation

(B) Paging helps solve the issue of external fragmentation

(C) Paging incurs memory overheads

(D) Multi-level paging is necessary to support pages of different sizes

Key: (B,C)

Sol: Paging: does not suffer from external fragmentation.

Paging: suffers from internal fragmentation.

Page tables are memory overheads, so, option C is also correct.

52. A five-state pipeline has stage delays of 150, 120, 150, 160 and 140 nanoseconds. The registers that are used between the pipeline stages have a delay of 5 nanoseconds each.

The total time to execute 100 independent instructions on this pipeline, assuming there are not pipeline stalls, is _____ nanoseconds. **[2-Marks, NAT]**

Key: (17160)

Sol: Cycle time = max delay stage + register delay = 160 + 5 = 165

Execution time of 100 instructions :

(5 + 99) * 165 = 17160

Alternative Explanation:

Let Tp denote cycle duration of the pipeline processor

Tp = max(stage delay)+Buffering Overhead

Tp = max(150, 120, 150, 160, 140)+ 5

Tp = 165 Nano seconds

Time required to execute N instruction = (K +(n-1))Tp

n = 100

K = 5

Hence (5+99)*165 = 17160

53. Consider the following ANSI C program.

```
# include <stdio.h>
int main
{
    int i, j, count;
    count = 0;
    i = 0;
    for (j  = −3; j < = 3; j++)
    {
                if ((j . = 0 && (i++))
                    Count = count + j;
    }
    count = count + i;
    printf ("%d", count);
    return 0;
}
```

Which one of the following options is correct? **[2-Marks, MCQ]**

(A) The program will not compile successfully

(B) The program will compile successfully and output 13when executed

(C) The program will compile successfully and output 8 when executed

(D) The program will compile successfully and output 10 when executed

Key: (D)

Sol: The program will compile successfully.

When j goes from -3 to -1, then "i++" and "count = count + j" statements do not execute.

When j = 0, count = 0, i = 1.

When j = 1, count = 1, i = 2.

When j = 2, count = 3, i = 3.

When j = 3, count = 6, i = 4.

Then for loop terminates, and count = count + i , So, count = 10.

54. Consider a computer system with a byte-addressable primary memory of size 2^{32} bytes. Assume the computer system has a direct-mapped cache of size 32 KB (1 KB = 2^{10} bytes), and each cache block is of size 64 bytes.

The size of the tag field is _____bits. **[1-Mark, NAT]**

Key: (17)

Sol: Cache block size is 64 bits, so block offset = 6 bits

Number of cache lines = 32KB / 64 B = 512 lines

So, bits for line number = 9

So, tag bits = 32 - 6 - 9 = 17

55. Define R_n to be the maximum amount earned by cutting a rod of length n meters into one or more pieces of integer length and selling them. For i> 0, let p[i] denote the selling price of a rod whose length is 1 metres. Consider the array of prices:

$$p[1]=1, p[2]=5, p[3]=8, p[4]=9, p[5]=10, p[6]=17, p[7]=18$$

Which of the following statements is/are correct about R_7? **[2-Marks, MSQ]**

(A) R_7 is achieved by three different solutions

(B) $R_7 = 19$

(C) R_7 cannot be achieved by a solution consisting of three pieces

(D) $R_7 = 18$

Key: (A,D)

Sol: R7 = 18 is maximum.

We can achieve it by three ways :

Way 1 : Take P[7]

Way 2 : Take P[6] , P[1]

Way 3 : Take P[3], P[2], P[2]

So, option A,D are correct.